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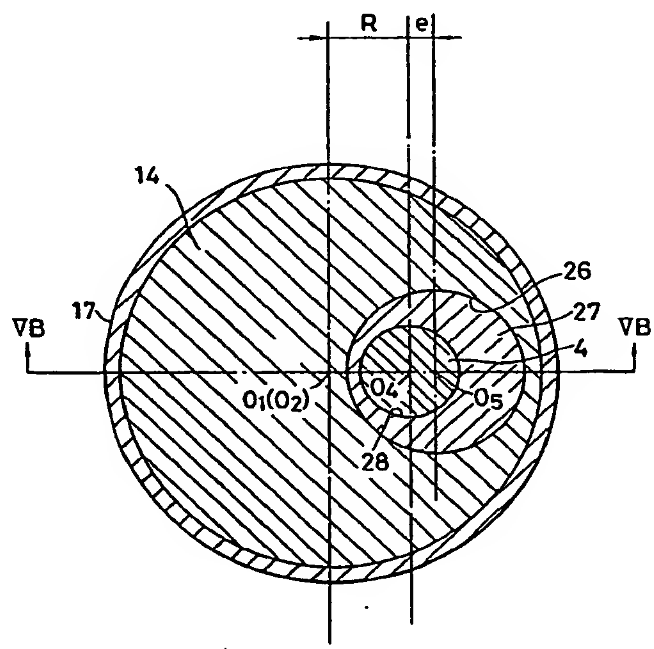
(54) **Scroll-type hydraulic machine.**

(57) A scroll-type hydraulic machine, e.g. a scroll-type compressor, having a small size and improved sealing between scroll members. An orbiting scroll is interleaved with a stationary scroll. A crank mechanism (14, 27) is provided for causing the orbiting scroll to undergo an orbiting motion. The crank mechanism includes a crank-shaft (14) and an eccentric ring (27) rotated in an eccentric pattern by the crankshaft. Orbital movement is transmitted from the eccentric ring (27) to a shaft (4) of the orbiting scroll. The distance between the center of rotation (O_2) of the crankshaft (14) and the center (O_4) of the orbiting scroll shaft (4) is made substantially equal to the crank radius (R) when the center of rotation (O_2) of the crankshaft (14), the center (O_4) of the orbiting scroll shaft (4), and the center of rotation (O_5) of the eccentric ring (27) are arranged along a straight line in the stated order.



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SCROLL-TYPE HYDRAULIC MACHINE

This invention relates to scroll-type hydraulic machines.

In order to facilitate an understanding of the present invention, it is helpful to describe the principles of the scroll-type hydraulic machine briefly.

Figs. 1A to 1D of the accompanying drawings show the fundamental components of a scroll-type compressor, which is one application of a scroll-type hydraulic machine, and illustrate the principles of the gas compression function thereof. In Figs. 1A to 1D, reference numeral 1 depicts a stationary scroll, 2 an orbiting scroll, 5 a compression chamber defined between the stationary and orbiting scrolls 1 and 2, 6 a suction chamber, and 8' a discharge chamber formed in the innermost portion of an area defined between the scrolls 1 and 2. The character O depicts a center of the stationary scroll 1 and O' a fixed point on the orbiting scroll 2. The orbiting scroll 2 has the same shape as that of the stationary scroll 1 but with the opposite direction of convolution. The convolution may be in the form of an involute or a combination of involutes and arcs. The compression chamber 5 is formed between the convolutions.

In operation, the stationary scroll 1, in the form of an involuted spiral having the axis O, and the orbiting

scroll 2 in the form of an oppositely involuted spiral of the same pitch as the stationary scroll 1 and having the axis O', are interleaved as shown in Fig. 1A. The orbiting scroll 2 orbits continuously about the axis of the stationary scroll through positions as shown in Figs. 1B to 1D without changing the attitude thereof with respect to the scroll 1. With such motion of the orbiting scroll 2 with respect to the stationary scroll 1, the volume of the compression chamber 5 is periodically reduced, and a fluid, for example a gas taken into the compression chamber 5 through the suction chamber 6, is compressed, then fed to the discharge chamber 8' formed in the center portion of the stationary scroll 1, and finally discharged through a discharge hole 8 formed in a supporting plate of the stationary scroll.

The distance OO' between the points O and O', that is, the crank radius, which is maintained constant during the orbital movement of the orbiting scroll 2, can be represented by:

$$OO' = \frac{P}{2} - t,$$

where P is the distance between adjacent turns of the spiral and corresponds to the pitch thereof and t is the thickness of the wall forming the spirals.

Further structural details and details of the

operation of the conventional scroll-type compressor will be described with reference to Figs. 2 and 3.

Fig. 2 shows in cross section a scroll-type compressor used in a refrigerator or air conditioner to compress a refrigerant gas. In Fig. 2, the stationary scroll 1 is formed integrally with a base plate 1a, which also constitutes a portion of a cell as described below. The orbiting scroll 2 is formed integrally with and extends upwardly from the upper surface of a base plate 3. A rotary shaft 4 of the orbiting scroll 2 extends downwardly from the lower side of the base plate 3. The suction chamber 6, which is formed peripherally of the scrolls, is connected to a gas intake part 7. A discharge port 8 formed in the base plate 1a of the stationary scroll opens to the discharge chamber 8'. A thrust bearing 9 supports the base plate 3 of the orbiting scroll 2. The bearing 9 is supported by a bearing support 10, which is in turn fixedly supported by the stationary scroll 1 by means of bolts or the like.

An Oldham coupling 11 provides orbital movement of the orbiting scroll 2 with respect to the stationary scroll 1. An Oldham chamber 12 is formed between the base plate 3 of the orbiting scroll 2 and the bearing support 10. A return path 13 for lubricating oil formed in the bearing support 10 communicates the Oldham chamber 12 formed in the bearing support 10 with a motor chamber described later. A crankshaft 14 receives the shaft 4 of the orbiting scroll 2

eccentrically to allow the orbiting scroll 2 to orbit. A passage 15 formed eccentrically in the crankshaft 14 feeds lubricating oil to an orbital bearing 16 provided eccentically in the crankshaft 14 which supports the shaft 4 of the orbiting scroll 2. A main bearing 17 supports an upper portion of the crankshaft 14, while a lower portion thereof is supported by a bearing 18. A motor is provided of which a stator 19 is stationarily supported and a rotor 20, together with a first balancer 21, is fixedly secured to the crankshaft 14. A second balancer 22 is fixedly secured to a lower end of the rotor 20. These components are disposed together in an airtight case 23. An oil reservoir 24 is provided in a bottom portion of the case 23, and a space 25 is provided in the case 23 for components associated with the motor.

In operation, when current is supplied to the windings of the motor stator 19, the rotor 20 produces a torque, thereby rotating the crankshaft 14. Upon rotation of the crankshaft 14, the shaft 4 of the orbiting scroll 2, supported by the orbiting bearing 16 provided eccentrically of the crankshaft 14, orbits with respect to the stationary scroll 1, and thus the orbiting scroll 2 orbits under the guidance of the Oldham coupling 11 through the states shown in Figs. 1A to 1D to compress gas as mentioned previously. That is, the gas sucked through the intake port 7 and the intake chamber 6 formed in the outer peripheral portion of

the orbiting scroll 2 and introduced into the compression chamber 5 is forced inwardly with the rotation of the crankshaft 14 to be compressed and then discharaged through the discharge port 8 communicated with the discharge chamber 8' where the pressure of the gas is a maximum.

Although the orbital movement of the orbiting scroll 2 due to the rotation of the crankshaft 14 tends to produce undesirable vibration of the compressor due to a mechanical mass unbalance, the first balancer 21 and the second balancer 22 provide static and dynamic balances about the crankshaft 14 so that the compressor operates without abnormal vibration.

Figs. 3A and 3B show portions of the compressor in Fig. 2 in more detail. Specifically, Fig. 3A shows a vertical cross-sectional view of a portion including the stationary scroll 1, the orbiting scroll 2, the shaft 4 of the orbiting scroll, the crankshaft 14 and the support member 10, wherein the shaft 4 is urged to one side of the orbiting bearing 16 due to the centifugal force of the orbiting scroll 2, including the base plate 3. Fig. 3B is cross-sectional view taken along a line IIIB-IIIB in Fig. 3A. In Fig. 3B, O_1 is an axis of the main bearing 17, O_2 is an axis (rotational center) of the crankshaft 14, O_3 is the axis of the orbiting bearing 16, and O_4 is the axis (center) of the shaft 4 of the orbiting scroll member. Further in Fig. 3B, F_C represents the centrifugal force (radial load)

produced by the orbiting scroll 2 and the base plate 3, r the eccentricity of the orbiting bearing 16 relative to the crankshaft 14, d_1 the bearing gap of the orbiting bearing 16, d_2 the bearing gap of the main bearing 17, B is the width of a groove between adjacent turns of the spiral arm of the stationary scroll 1, D the actual orbiting distance of the orbiting scroll 2, t_1 the thickness of the wall of the orbiting scroll 2, and C and C_1 radial gaps between turns of the stationary scroll 1 and the orbiting scroll 2. Generally $C = C_1$.

In the conventional scroll-type compressor as described above, the orbiting distance D of the orbiting scroll 2 can be represented as follows:

$$\begin{aligned} D &= 2\ (r + d_1/2 + d_2/2) + t_1 \\ &= 2r + t_1 + d_1 + d_2. \qquad \ldots\ldots(1) \end{aligned}$$

Therefore, the radial gap C between the turns of the stationary scroll 1 and the orbiting scroll 2 is:

$$\begin{aligned} C &= (B - D)/2 \\ &= (B - 2r + (t_1 + d_1\ \ d_2))/2 \\ &= ((B - 2r - t_1) - (d_1 + d_2))/2. \qquad \ldots\ldots(2) \end{aligned}$$

In the conventional scroll-type compressor, the term $(B - 2r - t_1)$ in equation (2) is larger than $(d_1 + d_2)$, and therefore the radial gap C is always present between the stationary scroll 1 and the orbiting scroll 2. In the normal operation of the compressor, however, in addition to

the centrifugal force F_c, a gas compression load F_g, which acts orthogonal to the centrifugal force F_c, acts on the shaft 4 of the orbiting scroll 2 as shown in Fig. 4, and therefore a composite force F of the forces F_c and F_g acts on the shaft 4 in the indicated direction. Accordingly, the radial gap C' between the turns of the stationary and orbiting scrolls 1 and 2 is larger than the radial gap C with only the centrifugal force F_c acting thereon.

With the presence of the radial gap C or C', there can be no contact between the stationary and orbiting scrolls 1 and 2 during the operation of the scroll compressor, and thus there is no problem of abrasion of side surfaces of the scroll walls. However, it is very difficult to seal the radial gap of the compression chamber, and hence there is a strong possibility of gas leakage from the compression chamber 5 through the radial gaps C and C' to the intake side. If gas in the compression chamber 5 leaks to the upstream side, the amount of gas finally discharged through the discharge post 8 is reduced, thereby reducing the volumetric efficiency of the compressor. Further, since the leaked gas has to be compressed again, the power consumption of the motor increases and the coefficient of performance is lowered.

In order to resolve these problems, it may be effective to set the term $(d_1 + d_2)$ in equation (2) larger

than the term (B - 2r - t) to thereby improve the sealing of the radial gaps. In such an approach, however, it is necessary to make both the bearing gaps d_1 and d_2 large enough to make (d_1 + d_2) always larger than (B - 2r - t) at any angular position of the crankshaft. However, there are unavoidable variations of the value (B - 2r - t) due to manufacturing variations in the groove width B, eccentricity r and wall thickness t_1. There are, of course, optimum values of the bearing gaps to provide a sufficient lubricating effect, which is a fundamental necessity, and if the bearing gaps are made larger than the optimum values, the lubricating functions of the bearing may be significantly lowered. Therefore, the manufacturing tolerances of the groove width B, the eccentricity r and the wall thickness t_1 must be very tight. Further, if the positions of the center O of the stationary scroll 1 and the axis O_1 of the main bearing 17 are changed for some reason, in some cases, one of them may become quite large, causing C - C_1 to be not always zero, even if d_1 and d_2 are set as mentioned previously. Therefore, the positional accuracy of the stationary scroll 1 with respect to the axis O_1 of the main bearing 17 must be very high.

U.S. Patent No. 3,924,977 to McCullough discloses an improved radial sealing mechanism in which the orbiting scroll is linked to a driving mechanism through a radially compliant mechanical linkage, which also incorporates means

for counteracting at least a fraction of the centrifugal force exerted by the orbiting of the orbiting scroll. The radially compliant mechanical linkage can take one of several forms, among which a typical linkage includes a ball bearing mounted on the shaft of the orbiting scroll and has the outer periphery of the ball bearing connected to a crank mechanism through a swinging linkage or a sliding-block linkage, each associated with a plurality of springs. Both the swinging linkage and sliding-block linkage are complicated, relatively space consuming in structure, and require a considerable number of parts, causing the compressor to be expensive and bulky.

A simpler and more inexpensive structure to achieve improved radial sealing is shown in Japanese Laid-Open Patent Application No. 129791/1981. In this structure, a balance weight having a bushing is provided. The bushing is engaged through an eccentric swinging pin connected with a crankshaft. The balance weight counteracts the centrifugal force of the orbiting scroll and the bushing functions to utilize a component of a compression load to provide a force which urges together the orbiting scroll and stationary scroll, thereby providing improved radial sealing. In the latter structure, however, the balance weight conteracting the centrifugal force of the orbiting scroll is indispensable, which requires a large space behind the orbiting scroll, leading to a difficulty in arranging a

thrust bearing for the crankshaft.

An object of the present invention is to overcome at least one of the above-mentioned problems inherent to conventional scroll-type hydraulic machines.

Accordingly, the present invention provides a scroll-type hydraulic machine in which a crank mechanism for providing orbital movement of an orbiting scroll includes a crankshaft and an eccentric ring capable of rotating about the crankshaft. A shaft of the orbiting scroll is orbited through the eccentric ring. In accordance with the invention, when the center of rotation of the crankshaft, the center of the shaft of the orbiting scroll and the center of rotation of the eccentric ring fall along a straight line in the stated order, the distance between the center of rotation of the crankshaft and the center of the shaft of the orbiting scroll is substantially equal to the crank radius so that the radial force, which is mainly the centrifugal force due to the rotation of the orbiting scroll, is minimized without the need for a balance weight and/or springs. Also, the actual orbiting width D of the orbiting scroll can be varied, resulting in a realization of good radial sealing of the machine, and hence an improvement in the volumetric efficiency and the coefficient of performance of the machine.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Fig. 1A to 1D show a cross section of a scroll-type compressor in various operational positions and are used to explain the operating principles thereof;

Fig. 2 is a cross-sectional view of a conventional scroll-type compressor;

Fig. 3A is an enlaraged cross-sectional view of a portion of the compressor in Fig. 2 in a first state;

Fig. 3B is a cross-sectional view taken along a line IIIB-IIIB in Fig. 3A;

Fig. 4 is a view similar to Fig. 3B with the compressor being in another state;

Fig. 5A to 7 show main portions of a preferred embodiment of a compressor of the present invention of which Fig. 5A is a cross section of a crankshaft and an orbiting scroll shaft when fitted, Fig. 5B is a vertical cross section taken along a line VB-VB in Fig. 5A, Fig. 6 is a oblique view of the crankshaft and an eccentric ring when dissassembled, and Fig. 7 is an oblique view of the crankshaft and the orbiting scroll shaft when dissassembled;

Figs. 8 and 9 illustrate the mode of radial sealing according to the present invention; and

Figs. 10 and 11 show other embodiments of the present invention.

In Figs. 5A to 7, reference numeral 26 designates an

eccentric hole formed in the crankshaft 14 with a predetermined eccentricity with respect to the center of rotation of the crankshaft 14. An eccentric ring 27 made of a bearing material is fitted as shown in Fig. 6. The eccentric ring 27 can rotate with respect to the crankshaft 14. An orbiting bearing 28, fitted into an eccentric hole formed in the eccentric ring 27 with a predetermined eccentricity with respect to the center of rotation O_5 of the ring 27, supports the shaft 4 of the orbiting scroll 2 as shown in Fig. 7.

In Fig. 5A, an axis (center) O_1 of the main bearing 17 lies at approximately the center of rotation O_2 of the crankshaft 14. The center of the orbiting bearing 28 (and hence the center of rotation of the shaft 4 of the orbiting scroll 2) and the center of rotation of the eccentric ring 27 and (and hence the center of the eccentric hole 26) are designated by O_4 and O_5, respectively. The distance between O_1 (or O_2) and O_4, namely the length corresponding to the crank radius (the eccentricity of the shaft 4 of the orbiting scroll 2), and the distance between O_4 and O_5, are indicated by R and e, respectively.

In the structure of Figs. 5A and 5B, gaps may exist between the main bearing 7 and the crankshaft 14, between the eccentric hole 26 and the eccentric rings 27, and between the orbiting bearing 28 and the shaft 4 of the orbiting sroll 2. However, these gaps are not important in

understanding the present invention and are omitted from these Figures. Further, the crank radius R actually includes halves of the respective bearing gaps, which are very small and negligible.

The eccentric ring 27 is rotatable about the center O_5 within the eccentric hole 26. The distance between O_2 and O_4, which is substantially equal to R, is changed cyclically with the rotation of the eccentric ring 27 about the point O_5.

An important feature of this embodiment is that, when the center of rotation O_2 of the crankshaft 14, the center O_4 of the orbiting scroll 2 and the center of rotation O_5 of the eccentric ring 27 are arranged in that order along a straight line, the distance between O_2 and O_4 is substantially equal to the crank radius.

In the operation of the compressor thus constructed, the compression of gas is performed according to the principles illustrated in Figs. 1A to 1D. The load arising due to gas compression is transmitted from the shaft 4 of the orbiting scroll 2 to the eccentric ring 27, with the loading conditions being as shown in Fig. 8. The load includes two components, one being a radial load, mainly the centrifugal force F_c, and the other being a gas compression load F_g in a direction orthogonal to the radial load F_c. These load components act on the center O_4 of the shaft 4 of the orbiting scroll 2 as shown in Fig. 8.

Since the center of rotation of the eccentric ring 27 is O_5, the gas compression load component F_g produces a moment about O_5, which causes the eccentric ring 27 to be rotated about O_5. When the eccentric ring 27 rotates about O_5, the distance between O_2 and O_4, which corresponds to the crank radius, increases. With the increase of the distance between O_2 and O_4, a small gap C is formed between a turn of the stationary scroll 1 and a turn of the orbiting scroll member 2 adjacent the turn of the stationary scroll 1. The width of the gap is typically several decades of microns.

If the scrolls have an involuted shape, positions at which the radial gap between the spirals shown in Fig. 8 is a minimum are separated from a line on which the load component F_c acts by a distance corresponding to a radius a of an involuted base circle and lie on a straight line parallel to the direction of the component F_c.

Fig. 9 shows the eccentric ring 27 when it is rotated by a small angle of $\Delta\theta$ due to the gas compression load component F_g. In this state, the stationary scroll 1 is in contact with the orbiting scroll 2. Due to the rotation of the ring 27 by the angle of $\Delta\theta$, the center of the shaft 4 of the orbiting scroll 2 moves slightly from O_4 to O_4', making $O_2O_4' > O_2O_4$.

As can be seen in Fig. 9, due to a moment produced by the component F_g about the center of rotation O_5 of the eccentric ring 27, the length O_2O_4 corresponding to the

crank radius increases up O_2O_4' (actual crank radius), and the wall of the orbiting scroll 2 contacts the wall of the stationary scroll 1.

In the state shown in Fig. 9, the moments about O_5 are substantially balanced because the angle $\Delta\theta$ is small. It is physically shown that the orbiting scroll 2 contacts the stationary scroll 1 at least at two points on either side of O_4.

That is:

$$F_g \cdot e = f \cdot a. \times 2$$

Therefore, the contact force f between the orbiting scroll 2 and the stationary scroll 1 is given by:

$$f = \frac{e}{2a} \cdot F_g.$$

The load component F_c is also capable of producing a moment about O_5. However, this moment is negligible when $\Delta\theta$ is small. Hence, due to the small value of $\Delta\theta$, it is possible to make the orbiting scroll 2 contact the stationary scroll 1 as shown in Fig. 8.

Therefore, the contact force f is not substantially influenced by the centrifugal force F_c and is basically a function of only the gas compression load component F_g. When the rotational speed of the compressor is increased, the centrifugal force F_c increases correspondingly. However, the gas compression load component F_g does not change since it depends only upon the compression conditions. Therefore, the contact force f is

substantially constant, even when the rotational speed of the compressor is changed.

The radial gap between the orbiting scroll 2 and the stationary scroll 1 is sealed by utilizing the force acting orthogonally of the centrifugal force (the gas compression load component) during the operation of the compressor with substantially no influence of the latter force. Therefore, gas leakage from the compression chamber 5 is minimized, resulting in an increase of the volumetric efficiency. The power consumption of the motor also is reduced becaue recompression of leaked gas is not needed. Thus, the coefficient of performance of the compressor is improved. Since the crank radius can be varied, it is possible to tolerate greater variations in the machining and assembly of the various components of the compressor. That is, it is not always necessary to machine the groove of width B, the eccentric hole, the wall of thickness t, etc. with high precision, and there is no need of highly precise assembly techniques.

Further, as mentioned previously, the eccentric ring 27 is made of bearing material. Therefore, there is no need of providing bearing material parts inside the surfaces of the eccentric hole 26 and the orbiting bearing 28, making the construction of the compressor of the invention much simpler than the conventional machine.

As an example, if the length O_2O_4 corresponding to

the crank radius is 5 mm and e = 1 mm, an actual crank radius O_2O_4' becomes larger than O_2O_4 by ε, where ε is on the order of 50 μm. However, in order to facilitate the assembly of the machine, it is sufficient for ε to be about 0.1 mm at the maximum point. In such a case, there may be some slight influence of the centrifugal force; however it is negligible as a practical matter.

In the embodiment described hereinbefore, the eccentric ring 27 is fitted in the eccentric hole 26. Instead, however, it is possible to form an eccentric protrusion 29 on the crankshaft 14 which is fitted into an eccentric hole 30 formed in the eccentric ring 27, which is in turn inserted into an axial hole 32 formed in the shaft 4 of the orbiting scroll 2, with the outer periphery 31 of the eccentric ring 27 being in sliding contact with an inner wall of the hole 32, as shown in Fig. 10.

Another embodiment is shown in Fig. 11 in which a protrusion 33 is formed eccentrically on the end of crankshaft 14 on which the eccentric ring 27 is rotatably fitted, and the orbiting bearing 28 receives the shaft 4 of the orbiting scroll 2. In the embodiment shown in either Fig. 10 or Fig. 11, the distance between the center of rotation O_2 of the crankshaft 14 and the center O_4 of the orbiting scroll shaft 4 is made substantially equal to the crank radius.

As described hereinbefore, the present invention

resides in a scroll-type hydraulic machine in which the crank mechanism for providing orbital movement of the orbiting scroll includes the crankshaft and the eccentric ring capable of rotating about the crankshaft, the shaft of the orbiting scroll being orbited through the eccentric ring. When the center of rotation of the crankshaft, the center of the orbiting scroll shaft and the center of rotation of the eccentric ring are arranged along a straight line in the stated order, the distance betwen the center of rotation of the crankshaft and the center of the orbiting scroll shaft is made substantially equal to the crank radius. Accordingly, the radial force, which is mainly the centrifugal force due to the rotation of the orbiting scroll, is minimized without the need for a balance weight and/or springs asociated with the orbiting scroll, resulting in improved radial sealing of the machine and hence improvements of the volumetric efficiency and the coefficient of performance of the machine.

~~Furthermore according to the invention,~~ because the machine is insensitive to radial forces, it is particularly suitable to be applied to a scroll-type hydraulic machine which is operated at a variable speed.

Claims:

1. A scroll-type hydraulic machine characterised by: a stationary involuted first scroll member (1); an orbiting involuted second scroll member (2) interleaved with said first scroll member (1) for compressing a volume of fluid taken in when said second scroll member (2) is orbited with respect to said first scroll member (1); an orbiting scroll shaft (4) rigidly coupled to one end of said second scroll member; and a crank mechanism (14,27) and a bearing (17) for supporting said crank mechanism, said crank mechanism comprising a crankshaft (14) and an eccentric ring (27) rotatable with respect to said crankshaft (14), orbital movement of said orbiting scroll shaft (14) being provided by said crankshaft (14) through said eccentric ring (27), the distance between the center of rotation (O_2) of said crankshaft (14) and the center (O_4) of said orbiting scroll shaft (4) being substantially equal to the crank radius (R) when said center of rotation (O_2) of said crankshaft (14), said center (O_4) of said orbiting scroll shaft (4) and the center of rotation (O_5) of said eccentric ring (27) are arranged along a straight line in the stated order.

2. A scroll-type hydraulic machine as claimed in claim 1 characterised in that said eccentric ring (27) is rotatably fitted in a hole (26) formed eccentrically in said crankshaft (14), and said orbiting scroll shaft (4) is fitted in an orbiting bearing (28) formed eccentrically in said eccentric ring (27).

3. A scroll-type hydraulic machine as claimed in claim 1 or 2 characterised in that said eccentric ring (27) is made of a bearing material.

4. A scroll-type hydraulic machine as claimed in any one of claims 1 to 3 characterised in that an eccentric protrusion (29) is formed eccentrically on said crank-shaft (14) and fitted in an eccentric hole (30) formed eccentrically in said eccentric ring (27), and said eccentric ring (27) is received in an axial hole (32) formed in said orbiting scroll shaft (4) with an outer peripheral surface of said eccentric ring (27) being in contact with an inside wall of said axial hole (32).

5. A scroll-type hydraulic machine according to any one of claims 1 to 4 characterised in that said machine is a compressor.

PRIOR ART

FIG. 1A

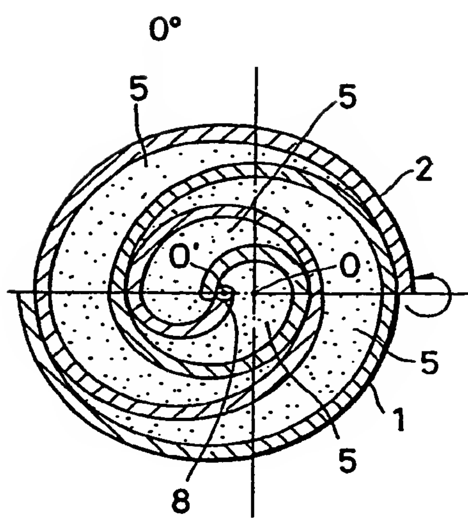


FIG. 1D

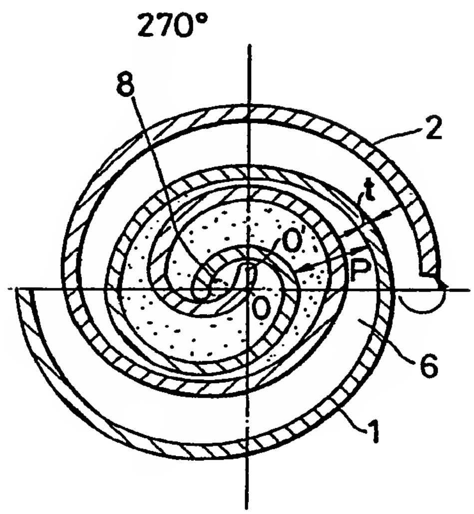


FIG. 1B

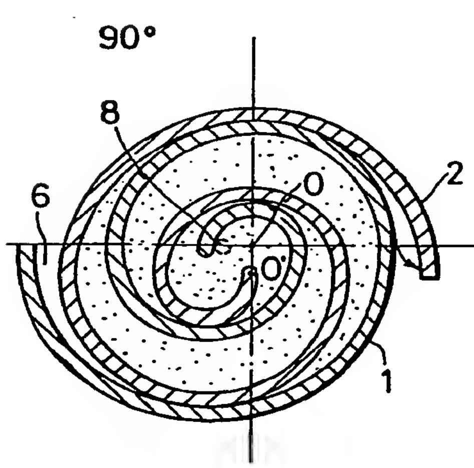


FIG. 1C

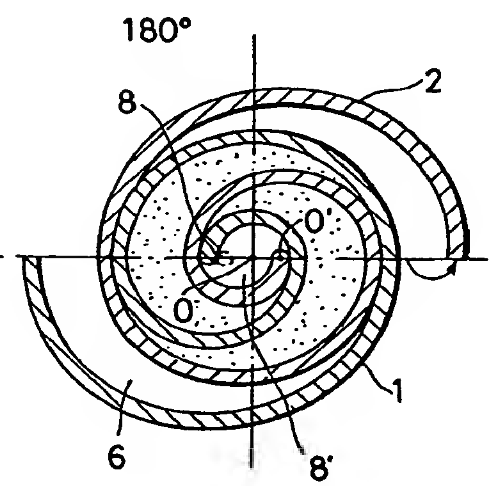


FIG. 2
PRIOR ART

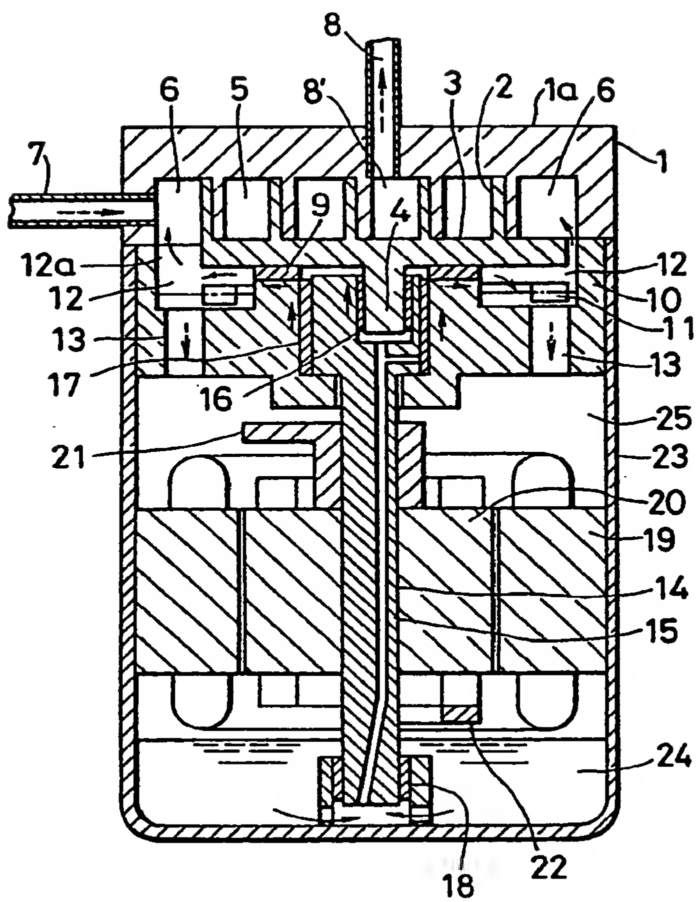


FIG. 3B
PRIOR ART

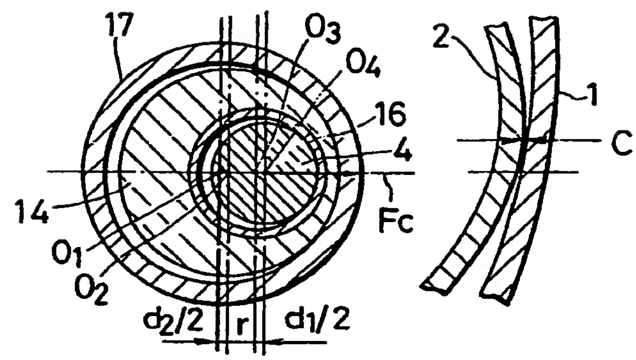


FIG. 3A
PRIOR ART

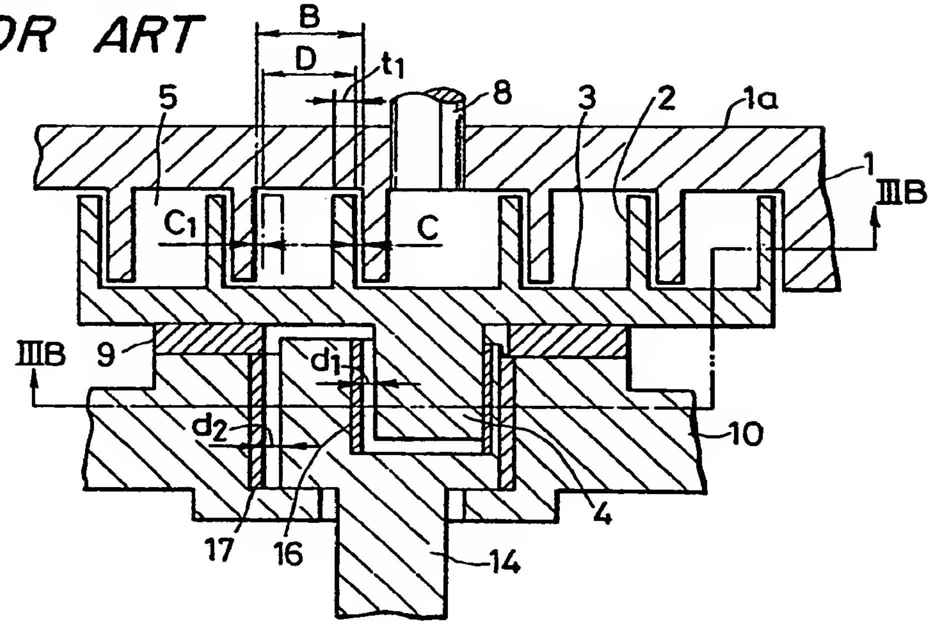


FIG. 4
PRIOR ART

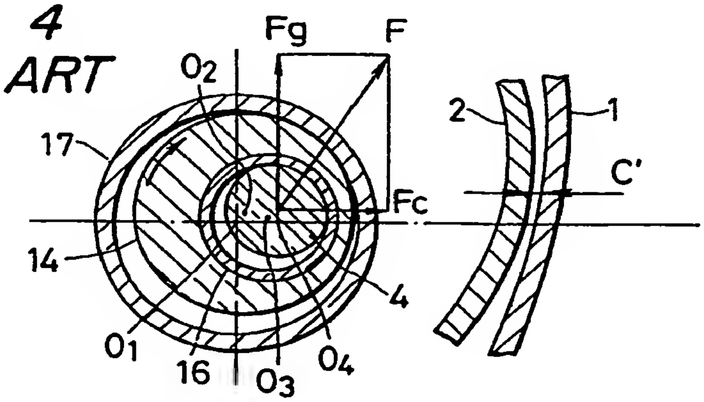


FIG. 5A

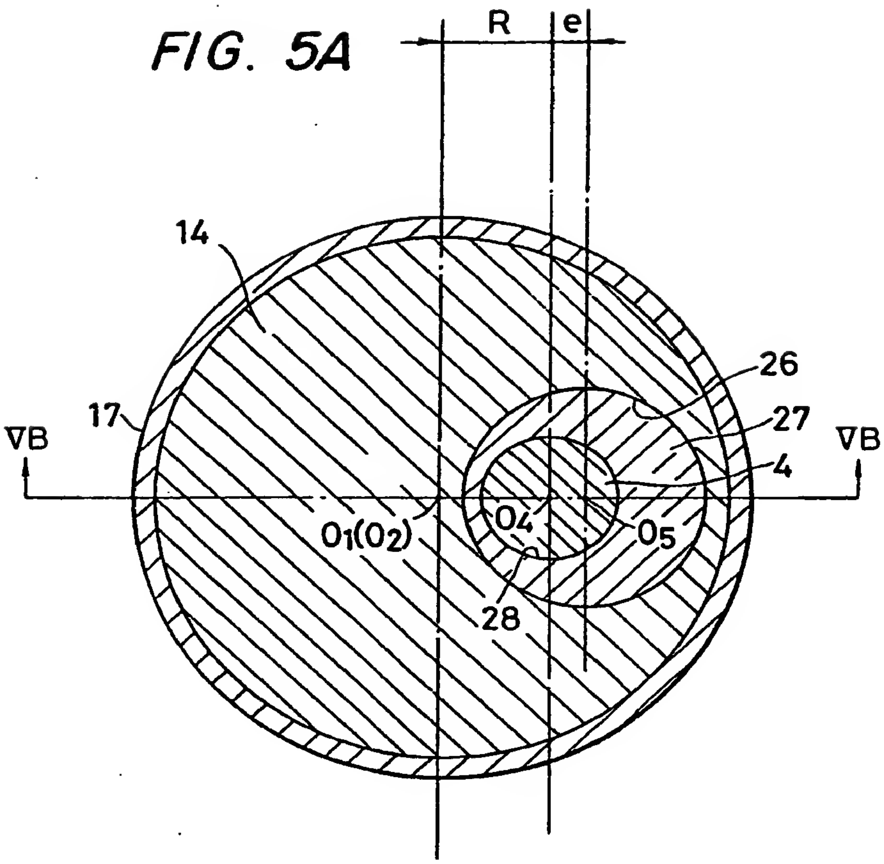


FIG. 5B

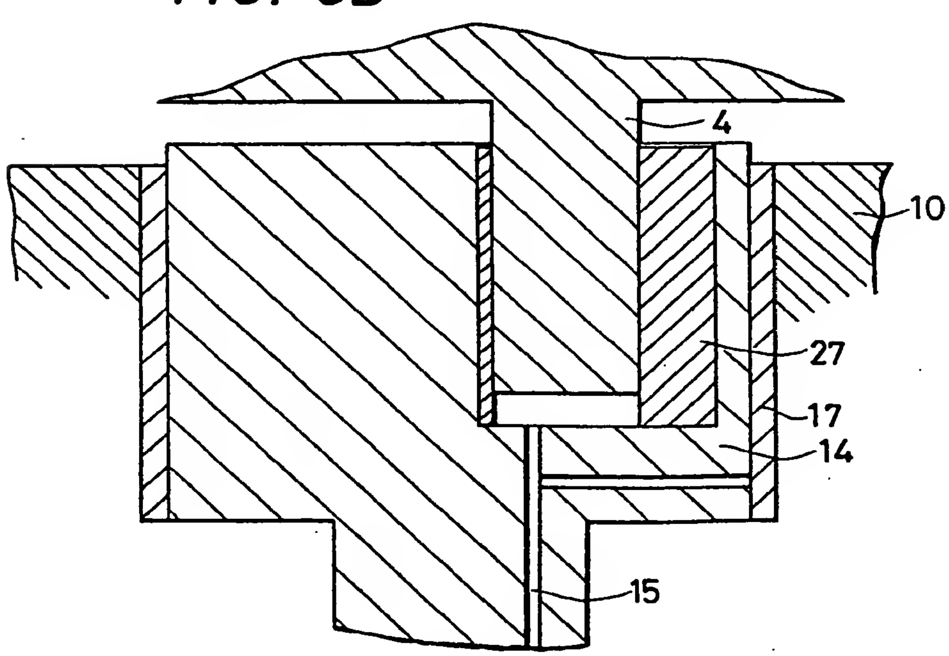


FIG. 6

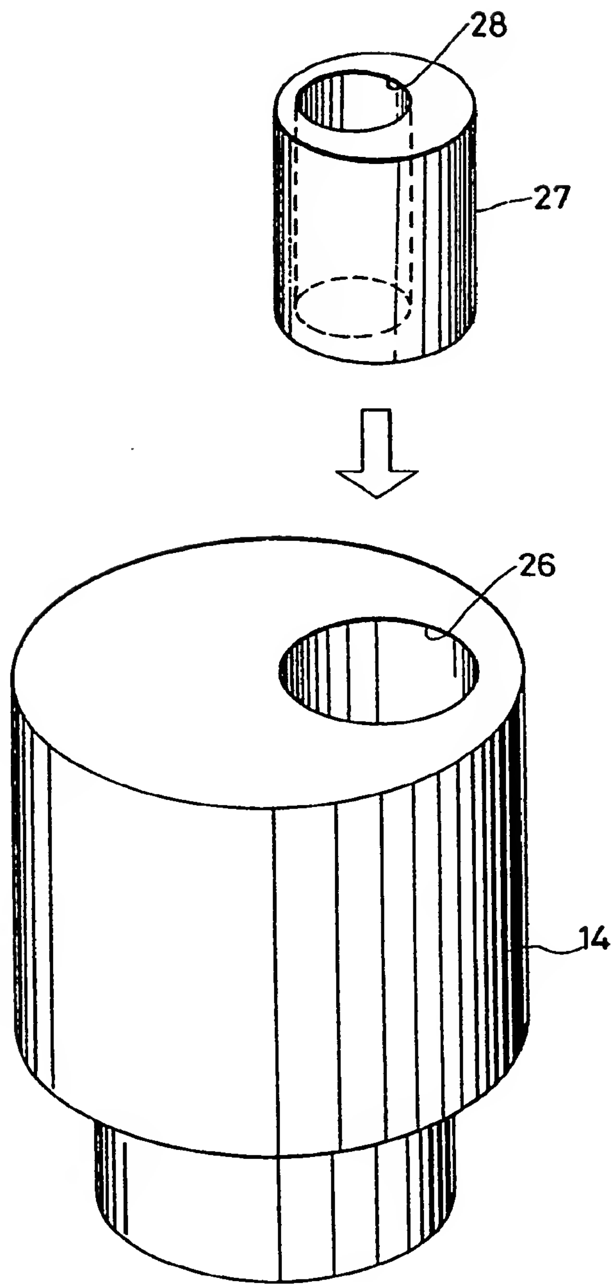


FIG. 7

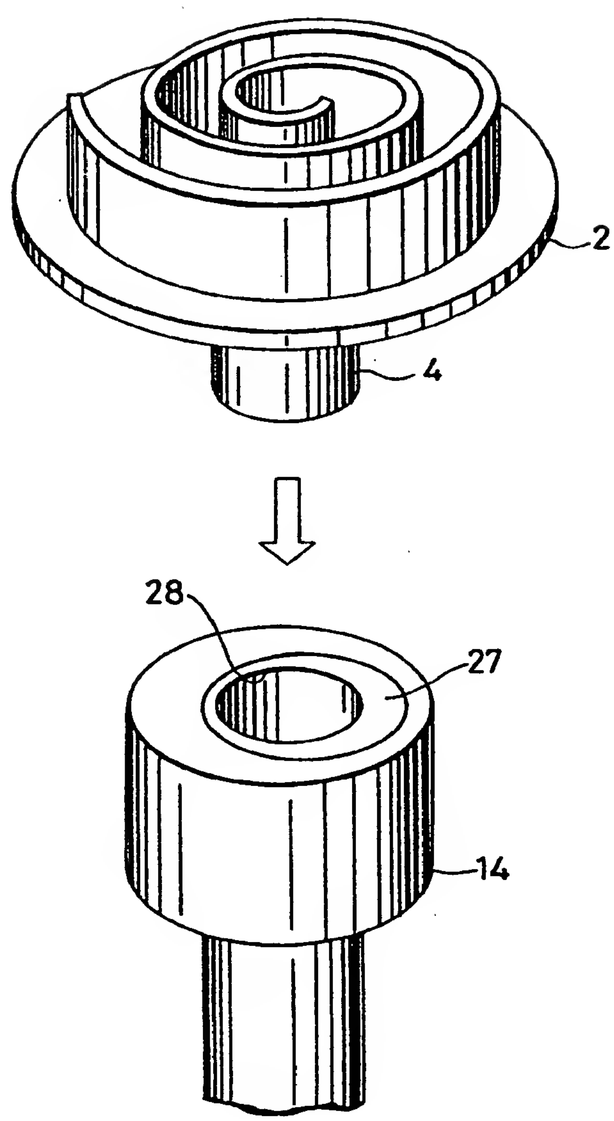


FIG. 8

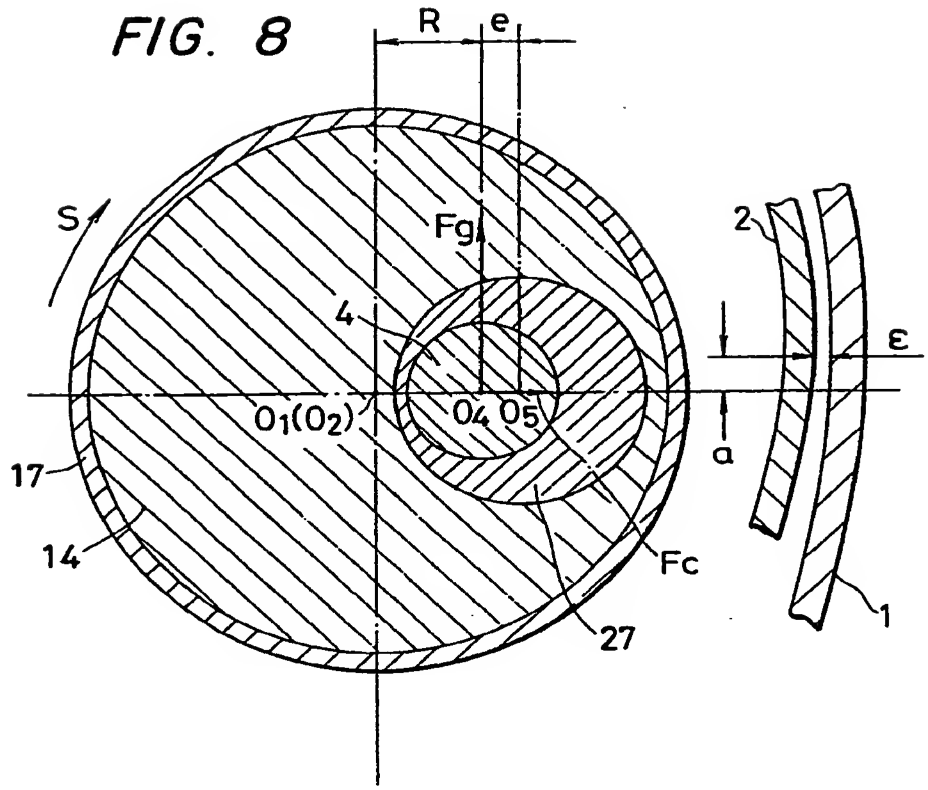

R
e
S
Fg
2
4
ε
$O_1(O_2)$
O_4
O_5
a
17
14
Fc
27
1

FIG. 9

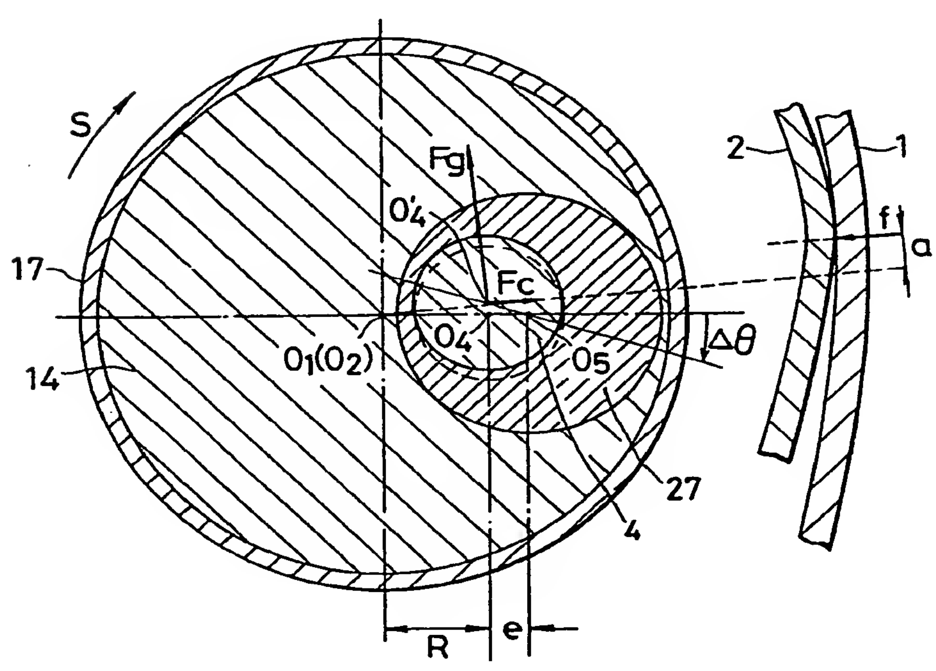

S
Fg
2
1
O_4'
f
a
17
Fc
$\Delta\theta$
$O_1(O_2)$
O_4
O_5
14
27
4
R
e

FIG. 10

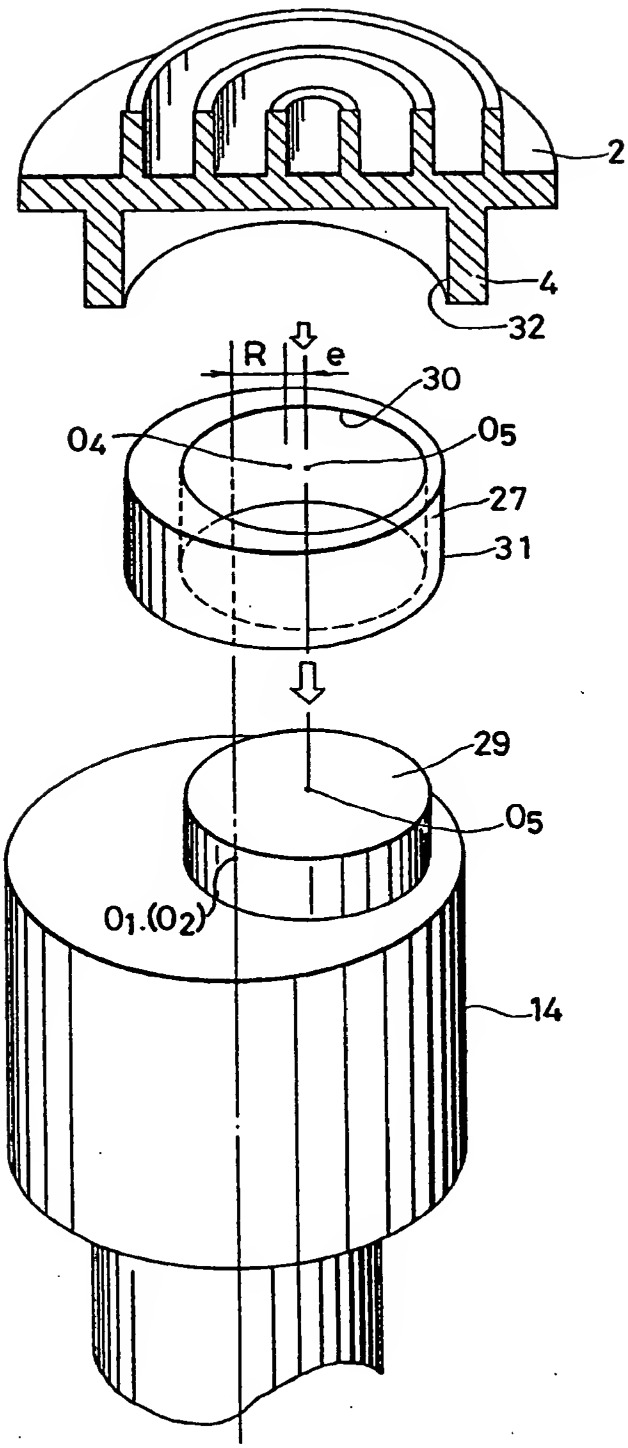
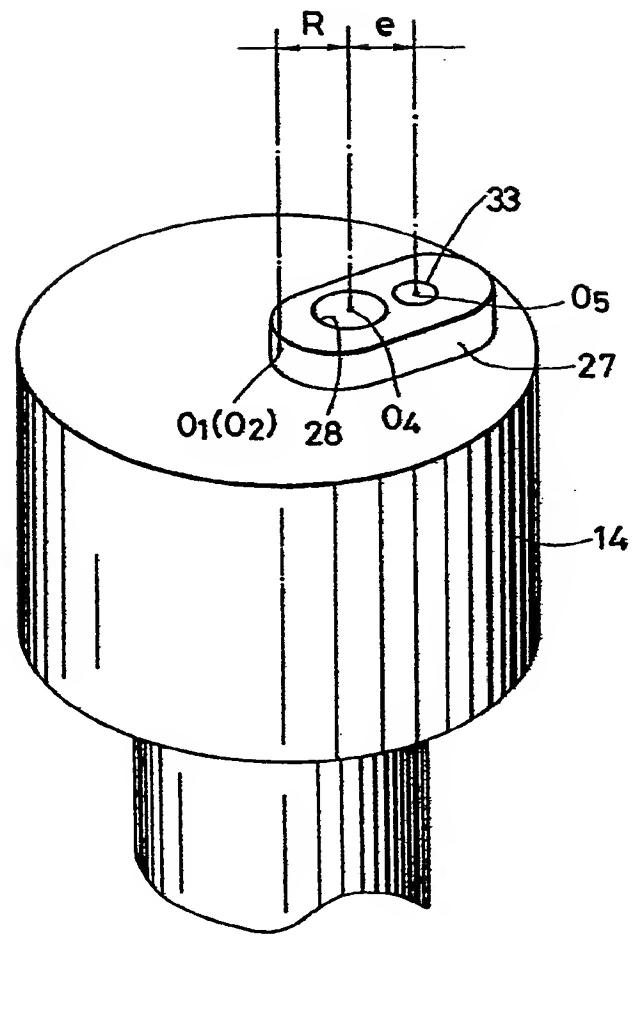


FIG. 11



European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 84103177.6

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
D,Y	US - A - 3 924 977 (MC CULLOUGH) * Column 8, line 61 - column 9, line 36; column 14, line 46 - column 15, line 12; fig. 5,10,21-23 *	1	F 04 C 18/02 F 01 C 1/02
Y	US - A - 1 906 142 (EKELÖF) * Page 3, line 95 - page 5, line 65; fig. 4-10 *	1	
A	EP - A1 - 0 037 658 (SANKYO ELECTRIC)		
D	& JP-A-129 791/81		

TECHNICAL FIELDS SEARCHED (Int. Cl. 3)

F 01 C 1/00
F 01 C 21/00
F 04 C 2/00
F 04 C 18/00
F 04 C 29/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	25-07-1984	WITTMANN

CATEGORY OF CITED DOCUMENTS

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